200099 USA

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 0 730 083 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
04.09.1996 Bulletin 1996/36

(51) Int Cl.[6]: **E21B 47/09**

(21) Application number: **96301366.9**

(22) Date of filing: **28.02.1996**

(84) Designated Contracting States:
DE FR GB NL

(30) Priority: **03.03.1995 US 397806**

(71) Applicant: **HALLIBURTON COMPANY**
Dallas, Texas 75381-9052 (US)

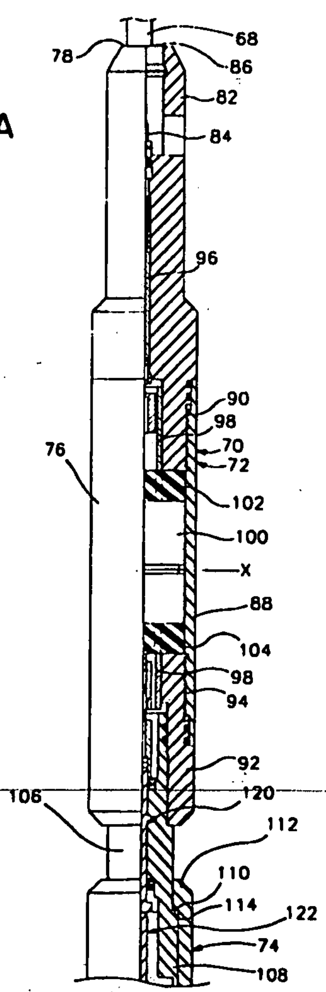
(72) Inventors:
- **Gazda, Imre I.**
  Fort Worth, Texas 76177 (US)
- **Goiffon, John J.**
  Dallas, Texas 75229 (US)
- **Cobb, Charles C.**
  Frisco, Texas 75034 (US)
- **Clemens, Jack G.**
  Plano, Texas 75023 (US)

(74) Representative: **Wain, Christopher Paul et al**
A.A. THORNTON & CO.
Northumberland House
303-306 High Holborn
London WC1V 7LE (GB)

(54) **Method and apparatus for use in setting barrier member in well**

(57) A locator and setting tool assembly (70), which is capable of locating and then setting a barrier member (200) within a cased wellbore or other string of tubular members in a manner such that the barrier member will not be set at a casing joint, includes a joint locator (72) and a setting assembly (74). The setting assembly (74) is connectable to the barrier member (200), eg a packer. In use, a planned barrier setting point within a cased wellbore is established based upon recorded well logs and customer requirements, and then an actual joint location is established and the barrier then set nearby.

FIG. 2A



Description

The present invention relates to a method and apparatus for use in setting a barrier member, such as a packer, plug or other lock, in a string of tubular members in a wellbore.

The use of plugs, locks and other barrier members in oilfield tubular members is well-known in the art. A packer assembly, as particularly described relative to a preferred embodiment herein, is normally installed to securely and sealingly engage the interior wall of a wellbore and provide fluid and pressure isolation between sections of the wellbore. Once the packer assembly is set, a tubing string may be inserted into the wellbore and latched into the packer assembly so that production operations may be conducted. When those operations have been completed, the tubing string is unlatched from the packer assembly and removed from the wellbore. A pulling tool may be run into the wellbore thereafter to engage the packer and unset it so that it may be removed from the wellbore.

Using conventional techniques, barrier members such as packers or locks are often set within casing string, tubing string or other string of tubular members with an explosive charge which rapidly expands portions of the barrier member to cause them to engage the inside walls of the surrounding tubular member, thus setting the member. The use of explosives for setting is not reliable, however, since a small asymmetries in the geometry of the explosion may cause the barrier member to become set off-centre within the tubular member making it more prone to failure under stress. Further, rapid setting, such as by explosive methods, may cause the setting elements of the barrier member to be structurally deformed during setting and thus weakened.

A packer assembly is typically intended to be placed in a wellbore at a particular depth from the surface, which depth is specified by the customer. For example, it may be desired to set the packer above a set of perforations in the casing. Proper placement and setting of a packer assembly, however, requires some information regarding the location at which the packer assembly is being set within the wellbore. Casing joints, the couplings between two casing sections, appear at intervals along the casing and present gaps or discontinuities in the casing wall which may prevent the packer assembly elastomeric sealing element from sealing properly at those locations. If the well operators can determine beforehand that the depth or location specified by the customer for placement of the packer assembly will result in the packer's sealing element being set at a casing joint, they can inform the customer and obtain guidance for adjusting the location for setting the packer assembly or receive other instructions.

Well operators normally try to avoid casing joints by correlating their estimate of the depth at which the packer assembly will be set with recorded depths of casing collars. Unfortunately, potential problems or inaccuracies with both sets of data often prevent a precise correlation. Because casing joints appear roughly every thirty feet (9.2m) along the wellbore, an inaccurate correlation risks undesired setting of a packer at a casing joint.

The operators obtain an estimation of the depth at which the tool will be positioned when it is disposed in the wellbore by physically measuring the length of the running arrangement used to dispose a tool into a wellbore. For example, if a tool is disposed into a wellbore on a 500 foot (152.5m) running string, it would be assumed that the tool would be disposed at a depth of 500 feet (152.5m) below the surface. However, running arrangements tend to stretch slightly in the wellbore, as a result of heat and weight, skewing the estimate. A 5/16" (7.9mm) monofilament cable has an average stretch rate of 1.2 ft/kft/klb (0.37m/305m/454kg). However, the rate of actual stretch will vary depending upon the weight of the bottom hole assembly and the depth at which the running arrangement is disposed. It is, therefore, difficult to obtain a precise actual depth estimate using only physical measurement of the running arrangement.

A casing collar locator log is made up when a casing string is run and lists the recorder depths at which the threaded casing collars that join adjacent casing sections at the casing joints will be found. Once the casing is cemented, the collars are intended to form permanent reference points for measuring depth. If the location of a casing collar is known, the planned location for setting of a packer can be adjusted upward or downward within the wellbore to avoid setting the packer at the casing joint. However, the casing collar locator log for an older well may be unavailable when needed. Also, older collars occasionally rust through and allow the portion of the casing string below the rusted collar to slip downward, altering the locations of the collars below. If an operator lacks accurate casing collar location information, reliable correlation with data from physical measurement of the running arrangement may be impossible.

We have now found a way of overcoming these problems.

According to the present invention, there is provided a locator and setting assembly for use in setting of a barrier member at a desired setting point within a string of tubular members in a wellbore, the locator and setting assembly being operably connectable to a barrier member setting tool and comprising:

a. a joint locator capable of detecting the location of joints between the tubular members of said string; and
b. a setting assembly which is capable of setting a barrier member within the wellbore.

The invention also provides a method of setting a barrier member within a string of tubular members in a wellbore, which method comprises the steps of:

a. establishing a desired setting point within said string, said desired setting point being based in part upon the recorded locations of joints between tubular members in said string;
b. sensing the actual location of at least one joint between tubular members in said string;
c. establishing an adjusted desired setting point based upon said sensed actual location; and
d. setting said barrier member proximate said adjusted desired setting point.

The invention preferably features an electrically powered locator and setting tool. This tool is capable of setting a barrier member within a cased wellbore or other string of tubular members and may be later modified and converted to a pulling tool which can unset and retrieve the barrier member from the wellbore. Prior to setting the barrier member, the locator and setting tool can position a barrier member, such as a packer or plug within a cased wellbore or other string of tubular members in a manner such that the barrier member will not be set at a casing joint.

In a preferred embodiment, the locator and setting tool preferably features a single tool arrangement made up of a composite housing containing a casing collar locator and a packer setting assembly. The casing collar locator includes a detection means which detects the actual locations of casing collars along a casing string. The locator then provides a signal indicative of these locations. The setting section of the tool includes a motor and an associated linear drive section or working assembly which will operate an attached retrievable packer assembly to set the packer assembly at a desired point in the wellbore.

A remote power source, usually located at the surface of the wellbore, supplies electrical energy to the locator and setting tool through an electrically conductive powerline which can be extended down through the wellbore. Because the locator and setting tool is preferably run into a wellbore by wireline, the power line is typically disposed along or within the wireline running arrangement. In instances where the locator and setting tool is run into the wellbore by tubing conveyance, the power line will be located within the rubing string.

In methods of operation described herein, a planned setting point within a cased wellbore is established based upon recorded well logs and customer requirements. The planned setting point is established at a point in the casing string where no joint is recorded. A packer assembly is disposed into a wellbore using the locator and setting tool to a point proximate the planned setting point according to physical measurement of the running arrangement. Via manipulation of the running arrangement, locations of casing collars around the planned setting point are detected by the casing collar locator. The detected depths of the casing collars are then compared to the recorded collar depths. If the detected and recorded depths match, the packer assembly may be set at the planned setting point. If there is a discrepancy between the detected and recorded collar depths, however, the customer can be informed and warned that setting the packer at the planned setting point may result in setting at a joint. The adjusted setting point is established in a portion of the wellbore where no casing joint has been detected which could prevent the barrier member from establishing or maintaining a fluid seal when set.

According to the methods herein described, the locator and setting tool is removably affixed to a retrievable packer assembly. The "offset distance," the approximate longitudinal distance from the casing collar locator's detection means and the sealing member of the packer assembly, is measured. A running arrangement and a power line are attached to the locator and setting tool. Once the setting point has been adjusted and verified as described, the locator and setting tool and the affixed packer assembly are disposed within the wellbore to the depth of the setting point. The packer assembly may then be set inside the wellbore by operation of the packer setting assembly. In preferred embodiments, a retrievable packer assembly is employed for later removal from the wellbore by operation of a modified locator and setting tool.

The setting assembly of the locator and setting tool features a setting assembly which is actuated by remotely transmitted power. In a preferred embodiment, the power is transmitted from a source at the surface of the well via a power line located within the running arrangement. The setting assembly features a gearmotor-driven working assembly which imparts opposing axial or longitudinal forces and motion to portions of the barrier member in order to set it within a wellbore. The distance of the opposing axial motion defines a setting stroke for the setting assembly.

Following setting of the barrier member and disengagement of the locator and setting tool from the barrier member, a clutch arrangement limits the length of the setting stroke for the setting assembly. The clutch arrangement prevents excessive opposing axial or longitudinal motion which might result in harm to the gearmotor or other components of the setting assembly.

In order that the invention may be more fully understood, embodiments thereof will now be described by way of example only, with reference to the accompanying drawings, wherein;

FIG. 1 is a schematic overall view showing one embodiment of locator and setting tool of the present invention, with an attached packer assembly, disposed within a wellbore;
FIGS. 2A-2E are a partial cross-sectional view of an embodiment of locator and setting tool constructed in accordance with the present invention, in connection with a retrievable packer assembly; and
FIG. 3 is a cross-section on the line 3-3 of FIG. 2C.

Referring first to Figure 1, a portion of cased wellbore is shown. The wellbore portion includes an inner metallic casing string 50 and a surrounding cement sheath 52 disposed within a potential subterranean petroleum producing zone 54. The casing string 50 encloses a wellbore 56 and includes an upper casing section 58 and lower casing section 60, which are jointed in a longitudinally, coaxial relation at a casing joint indicated generally at 62. It should be understood that the casing string 50 actually consists of a large number of connected casing sections. Only a single joint 62 is shown for purposes of illustration.

The casing joint 62 features a casing collar 64 of a type known in the art. The casing collar 64 surrounds and threadedly engages each casing section 58, 60 to join them. A gap 66 is located between the upper and lower casing sections 58, 60. A wireline 68 suspends packer setting tool 70 within the wellbore 56.

The casing collar locator section 72 includes a device or assembly for detecting casing mass changes that occur at collar joints. A number of suitable casing collar locator assemblies are known which use magnetic coil induction to detect changes in casing thickness. When the locator passes through a casing collar, the magnet/coil assembly outputs an induced current which results in a signal which is transmitted to the tool operators at the surface. An exemplary assembly will be described here in enough detail for the reader to understand its general operation. A preferred casing collar locator assembly is the Universal Casing Collar Locator Tool (UCCL) marketed by Halliburton Co. The UCCL uses a four coil, six magnet arrangement to detect casing changes. This type of device is commonly used with perforating gun arrangements.

Referring now to Figures 2A-2E, the locator and setting tool 70 is now described in greater detail. Where components of relatively well known design are employed, their structure and operation will not be described in great detail. Connections between components, although not specifically described in all instances, are shown schematically and comprise conventional connection techniques such as threading and the use of elastomeric O-ring or other seals for fluid tightness where appropriate. The use of terms such as "above." "upper," and "below" are used to identify the relative position of tool components as shown disposed within an exemplary wellbore and with respect to distance to the surface of the wellbore as measured along the wellbore path.

The locator and setting tool 70 is generally comprised of an upper casing collar locator section 72 and a lower setting section 74. As will be described, a portion of the setting section 74 is made up of a working assembly which is detachably connectable to a retrievable packer assembly.

An outer composite housing 76 encloses the locator and setting tool 70 and extends from the top 78 of the tool to its lower end 80. The top 78 of the tool 70 features an appropriate connector sub 82 to facilitate coupling of the housing 76 to a running arrangement such as wireline 68 by use of conventional means such as a clamp ring type cablehead assembly available from numerous commercial vendors including Halliburton Logging Systems of Houston, Texas and Titan Specialties, Inc. of Pampa, Texas. The sub 82 encloses an electrically conductive plug 84 which will engage a complimentary conductive device on the running arrangement. As FIG. 2A illustrates, the wireline running arrangement 68 includes a coaxially disposed power cable 86 which will engage the plug 84 when the wireline running arrangement has been connected at the upper end 78 of the tool 70 so that electrical power may be transmitted from the power cable 86 into the plug 84.

The connector sub 82 is affixed to an annular non-magnetic sleeve 88 at threaded connection 90. The non-magnetic sleeve 88 is preferably made up of a non-magnetic metal such as a beryllium, nickel or copper alloy. Similarly, the non-magnetic sleeve 88 is affixed to a lower sub 92 at threaded connection 94. The connector sub 82, sleeve 88 and lower sub 92 collectively enclose the casing collar locator section 72. As noted, the components making up the detector means of the casing collar locator are preferably the same as or similar to standard casing collar locator devices such as the UCCL. By way of background, however, they will be described now in limited detail. Within the casing collar locator section 72, an electrical conduit 96 extends downward from the plug 84 to a voltage protector device 98 such as a "double diode" assembly which protects electrical components of the casing collar locator section 72 during operation of the setting section 74.

A coil and magnet assembly 100 is positioned axially between upper and lower elastomeric shock absorbing elements 102 and 104, respectively. The operation of a coil and magnet assembly 100 to magnetically induce current changes in electrically energized coils upon detection of changes in metallic casing thickness is well known in the art and will not be described in further detail. It is noted that the coil and magnet assembly 100 functions as a detection means for determining in this manner the actual locations of casing collars and thus casing joints within a wellbore. In addition to this detection function. the casing collar locator section also generates a signal representative of these locations and transmits them to the surface using known techniques via a signal conduit (not shown) coaxially disposed within the wireline or other running arrangement. The voltage protector device 98 extends through each shock absorbing element 102, 104 and the coil and magnet assembly 100 to provide electrical power to the coil and magnet assembly 100.

A tubular neck member 106 extends between the casing collar locator section 72 and setting section 74 adjoining the two sections and forming a portion of the housing 76. The neck member 106 includes a radially enlarged lower end 108 which presents an upward fac-

ing engagement shoulder 110. An upper setting sub 112 forms a bell housing which surrounds the neck member 106 and presents an internal downwardly facing annular engagement shoulder 114 which is complimentary to the engagement shoulder 110. The upper setting sub 112 is connectable at its lower end to pin housing sub 116 by means of a threaded connection 118. When the upper setting sub 112 is fully engaged with the pin housing 116 and the threaded connection 118 is tightened, the shoulders 110 and 114 will be engaged as well, forming a secure connection between the casing collar locator section 72 and the setting section 74. An electrical feedthrough conduit 120 is centrally disposed within the neck member 106.

The remainder of the composite housing 76 is made up as follows. Pin housing 116 is affixed by means of a threaded connector 117 to a gearmotor housing 119. The gearmotor housing 119 is in turn affixed at threaded connection 121 to a jackscrew housing 123. Below the jackscrew housing 123, clutch housings 125 are threadedly affixed to the jackscrew housing 123. The clutch housings 125 include a reduced diameter lower end 127 and an external thread 129 by which cylindrical sleeve 160 is attached to the clutch housings 125. A number of radial bushings or packings 162 are enclosed within the lower end 127 and secured into place by a threaded end cap 164. Referring now to FIG. 2E, the cylindrical sleeve 160 is affixed at its lower end to a radially enlarged adapter sleeve 166 by means of an adapter fitting 168 and bushing sleeve 170. The adapter sleeve 166 contains a number of laterally-disposed assembly holes along its length which permit operators access to interior components and serve as vent holes. The lower end of the adapter sleeve 166 comprises the lower end 80 of the housing 76 of the tool 70 and presents a downwardly and outwardly-facing engagement shoulder 172 as well as an extension portion 174 of reduced external diameter.

Returning to FIG. 2B, the pin housing 116 encloses a setting assembly activating pin 122 which is fashioned of electrically conductive material to engage the electrical feedthrough conduit 120 when the casing collar locator section 72 and setting section 74 are connected as described above. A compression spring mechanism 124 surrounds pin 122 and biases it toward the conduit 120 to ensure this engagement. Insulator sleeves 126 surround the pin 122 to prevent transmitted electrical energy from being dissipated into the pin housing 116. The insulator sleeves 126 are preferably formed of ceramic or other non-conductive material. Electrical power transmitted to the pin 122 is relayed through suitable electronic components 128 to a controller board 130 and from there via controller wires 132 to gearmotor 134. Upon receiving electrical power through the components 128, the controller board 130 initiates operation of the gearmotor 134. The gearmotor 134 may be of any suitable type. For the embodiment described herein, a motor operating at 7500 rpm in an unloaded condition and approximately 5000 rpm in a loaded condition, and having a horsepower rating of approximately 1/30th of a horsepower has been found satisfactory. In this same embodiment, the gearmotor 134 is coupled through a gear box 136 which provides approximately 5000:1 gear reduction to a convention rotational drive assembly 138 to drive a jackscrew assembly generally indicated at 140.

Suitable commercially available gearmotors include Globe type BD DC motors such as the A-2400 motor available from the Globe Motor Division of Precision Mechnique Labinal, 2275 Stanley Ave., Dayton, Ohio 45404, (513) 228-3171. Also suitable are BD and BL DC permanent magnet planetary gearmotors such as the A-2430 motors from Globe Motors. The jackscrew assembly 140 is preferably a conventional assembly, such as those manufactured and sold by Warner Electric Brake & Clutch Co. of South Beloit, Illinois 61080, (815) 389-3771 as model R-1105 Ball Screw.

The rotational drive assembly 138, when actuated, will rotate an elongated collar member 139 about its own longitudinal axis within the jackscrew housing 123. A lubricated packing 141 and bearings 143 are disposed between the jackscrew housing 123 and the collar member 139. The collar member 139 is affixed at its upper end to the rotational drive assembly 138 and at its lower end to an axially rotatable sleeve assembly 144.

The jackscrew assembly 140 also includes a threaded shaft 142 which moves longitudinally, at least initially, in response to rotation of the outer sleeve assembly 144. In the preferred embodiment described herein, the threaded shaft 142 will be a 5 pitch shaft. The threaded shaft 142 includes an elongated threaded portion 146 and a generally smooth, polished lower extension 148. The threaded portion 146 is operationally associated with the sleeve assembly 144 by means of a plurality of ball bearings (not shown) which engage the threads of the threaded portion 146. The threaded shaft 142 further includes a pair of diametrically opposed keys, one of which is shown at 150, which cooperate with a clutch block 152 coupled to threaded shaft 142. As shown in FIG. 2E, the lower portion of the lower extension 148 is threadedly engaged via a conversion nut 176 to a generally cylindrical tension sub 178. Threaded connection 180 interconnects tension sub 178 with a guide bushing 182.

Returning now to FIG. 2C, the clutch housings 125 enclose a generally cylindrical sleeve 199 which includes a pair of diametrically opposed keyways 154 which extend along at least a portion of the length of the sleeve 199. Keys 150 extend radially outwardly from the threaded shaft 142 through the clutch block 152 to engage each of the keyways 154 in the sleeve 199 thereby preventing rotation of the threaded shaft 142 relative to the sleeve 199. The keys 150 are maintained within the clutch block 152 by means of pins 153. Reference to FIG. 3 helps to illustrate the relationship of these components.

Rotation of the sleeve assembly 144 in one direction will cause the threaded shaft 142, clutch block 152 and keys 150 to move longitudinally upwardly relative to the sleeve 199. An upper position for the keys 150 is shown at 150a in FIG. 2C. Rotation of the sleeve assembly 144 in the opposite direction causes the threaded shaft 142 and clutch block 152 to move longitudinally downwardly relative to the sleeve 199. To set a barrier member in the manner described in this preferred embodiment, the sleeve assembly 144 will need to be rotated so as to cause upward longitudinal movement of the threaded shaft 142. As will be appreciated by those skilled in the art, because movement of the shaft 142 occurs relative to the sleeve 199, operation of the setting section 74 results in a linear action drive or working assembly which is capable of generating force and motion in opposing axial or longitudinal directions simultaneously. As will be described shortly, the application of opposing axial or longitudinal forces and motion to portions of a barrier member may be used to set that barrier member within a wellbore. The upward movement of the threaded shaft 142 (and any affixed components) with respect to the sleeve 199 (and affixed components) is referred to as a setting stroke.

Above a certain level within the sleeve 199, as indicated in FIG. 2C, the sleeve 199 includes a relatively enlarged internal diameter bore 156 such that moving the clutch block 152 into the bore 156 removes the outwardly extending keys 150 from being restricted against rotational movement within the sleeve 199. Accordingly, continued rotation of the sleeve assembly 144 will also result in free rotation of the threaded shaft 142 within the sleeve 199. By placement of the enlarged internal diameter bore 156 a measured distance along the sleeve 199, the amount of axial movement of the threaded shaft 142 along the sleeve 199 can be established. The clutch function of the jackscrew 140 thereby serves as a safety device to prevent burn-out of the electric motor and also serves to limit the length of the setting stroke of the setting section 74.

Referring once more to FIGS. 2D-2E, the upper portion of an exemplary retrievable packer assembly 200 is shown in connection with the locator and setting tool 70 for location and setting of the packer assembly 200 within a wellbore. A preferred packer assembly of this type is the Otis Versa-Trieve Packer currently commercially available from Halliburton Energy Services, 2601 Beltline Road, Carrollton, Texas 75006, (214) 418-3000. Other retrievable packer assemblies may be suitable for use as well. Such packer assemblies are moveable between set and unset conditions by axial movement of a sleeve or other component to axially compress slips and sealing elements causing them to extrude or extend radially outward until they contact the casing wall of the borehole. A ratchet mechanism may be used to secure the axially displaced components of the packer assembly such that the packer is maintained in its set condition.

In order to aid in understanding of the invention, some general features of this packer assembly 200 will now be briefly described. The packer assembly 200 features a top sleeve 202 which is threadedly connected at 204 to an outer shear sub sleeve 206. The top sleeve 202 presents an inwardly-directed fishing neck 205 which is useful for retrieval of the packer assembly 200 in conventional ways such as by use of a fishing tool. It is noted that the outer diameter of the guide bushing 182 is shaped and sized to fit within the interior diameter of the sleeve 206 and be reciprocally moveable therewithin. The lower end of the shear sub sleeve 206 is threadedly engaged at 208 to a packer element sub 210. The packer element sub 210 includes an element support mandrel 213 which radially presents one or more elastomeric sealing elements 212. Located on either axial end of the sealing elements 212 are end members 214 (one shown). The sealing elements 212 may be moved between an unset condition, wherein they have a radially reduced diameter as shown in FIG. 2E, and a set condition (not shown) wherein the elements 212 are axially compressed by the end members 214 to a radially expanded condition. This manner of setting and unsetting of sealing elements is well known in the art. Lower portions of the packer assembly 200 (not shown) may further include sets of slips which are radially expandable in a similar manner to engage an inner casing wall and radially retractable to release the packer assembly 200 from engagement with the casing wall.

Located radially within the lower portion of the shear sub sleeve 206 is a packer mandrel 216 which is affixed by threading 220 at its lower end to mid mandrel 220 for joint reciprocal movement within the shear sub sleeve 206. A cylindrical guide tube 222 is disposed radially within the packer mandrel 216 and mid mandrel 220 axially below the guide bushing 182. Upward axial movement of the packer mandrel 216 and mid mandrel 220 with respect to the shear sub sleeve 206 will cause the slips (not shown) and sealing elements 212 of the assembly 200 to be moved into their set conditions.

The locator and setting tool 70 is removably affixed to the packer assembly 200 in the following manner. Shear pins 184 affix the guide bushing 182 to packer mandrel 216. It is important that the shear pins 184 provide a total shear resistance force which is greater than the amount of force required to set the packer assembly 200, but less than the maximum amount of axial force which can be generated through operation of the rotational drive assembly 138 by the gearmotor 134. In one preferred embodiment, four shear pins are used which present a total shear resistance force of 6000 pounds. The shear pins 184 can be emplaced to connect these components only when the threaded shaft 142 of the jackscrew assembly 140 is axially extended to nearly its fullest length. Once the shear pins 184 have been emplaced to connect the guide bushing 182 and packer mandrel 216, the extension portion 174 is disposed within the upper end of the upper sub 202 until the engagement shoulder 172 of the sleeve 166 abuts the upper

end of the upper sub 202 as shown in FIG. 2E.

When affixed as described, upward axial movement of the tension sub 178 of the tool 70 within the shear sub sleeve 206 results also in upward axial movement of the guide bushing 182, packer mandrel 216 and mid mandrel 218 within the shear sub sleeve 206. Similarly, the slips and sealing elements 212 will be unset when the packer mandrel 216 and mid mandrel 218 are forced downward with respect to the shear sub sleeve 206.

During a typical setting operation, the setting section 74 is operated to set the packer assembly 200 and then to release the locator and setting tool 70 from the emplaced packer assembly 200. Actuation of the rotational drive assembly 138 by the gearmotor 134 will result in the upward longitudinal or axial movement of the threaded shaft 142 from rotation of the outer sleeve assembly 144. The lower extension 148 of the shaft 142 will be drawn axially upward along with the conversion nut 176, tension sub 178, guide bushing 182, packer mandrel 216 and mid mandrel 218. During this movement. the top sleeve 202, outer shear sub sleeve 206 and end members 214 of the packer element sub 210 are prevented from upward movement by the engagement of the upper sub 202 with the adapter sleeve 166 of the locator and setting tool 70, and upward axial movement of the described components occurs with respect to these. As a result of this relative movement, the packer assembly 200 is moved to its set position.

As the upward movement of the shaft 142 continues, shear pins 184 are sheared allowing the guide bushing 182 to separate from the packer mandrel 216 and move upwardly with respect to it. The guide bushing 182 can then be drawn toward and ultimately into the adapter sleeve 166. At this point, the locator and setting tool 70 is released from the packer assembly 200 and can be withdrawn from the casing string 50 while leaving the packer assembly 200 set within the casing string 50.

Following the setting operation, the clutch function described previously will cause the linear type drive action of the setting section 74 to cease by permitting free rotation of the threaded shaft 142 rather than forced linear movement. The clutch arrangement thereby serves to define the length of the setting stroke provided by the setting section 74. If, for example, a linear displacement of the threaded shaft 142 (and affixed components) of 8 inches is needed to set the packer assembly 200 and to cause full disengagement of the locator and setting tool 70 from the packer assembly 200, the setting stroke may be defined by the clutch arrangement to be just greater than that amount (i.e. 8.25 inches).

In operation, the locator and setting tool 70 is used to first locate and then to set a packer assembly 200 within the wellbore 56. The locations of desired setting points for packers are typically supplied prior to packer setting and are expressed in terms of a depth below the surface. The running arrangement should be physically measured, either prior to or during the running operation, so that the packer assembly 200 will be placed proximate the planned desired setting point. Prior to running the tool 70 and affixed packer assembly 200, it is preferred that a measurement be taken to determine the distance between a reference point "X" at a central portion of the casing collar locator section 72 (See FIG. 2A for illustrative position) and a reference point "Y" at a central portion of the sealing elements 212. This should provide an approximate "offset distance" by which the position of the tool 70 and affixed packer assembly 200 should be adjusted upward within the wellbore 56 prior to setting the packer assembly 200.

Once a planned desired setting point has been provided, the locator and setting tool 70 and packer assembly 200 are disposed within the wellbore 56 on wireline 68 at least to the depth of the desired setting point using the running arrangement physical measurement. Preferably, the packer setting tool 70 is lowered several hundred feet below the planned desired setting point.

Next, the tool 70 is slowly raised within the wellbore 56. The casing collar locator section 72 will detect the actual location of casing joints such as 62 as the casing collar locator section 72 passes the joint. Readings from the casing collar locator section are transmitted to the surface. These readings are recorded on a log and compared to the depths of casing collars recorded in the well's casing collar locator log and/or other previous logs or records which detail the collar locations in order to reconcile the two sets of data. If no meaningful discrepancies between the two sets of data exist, the tool 70 and packer assembly 200 may be disposed to the planned desired setting point and then set within the wellbore.

If, during the comparison, any discrepancies between the two sets of data are noted. The process may be repeated to verify that the readings from the casing collar locator section 72. If discrepancies continue to exist, the packer assembly 200 should not be set, and the customer should be notified to obtain instructions as to how to proceed. The customer should be informed that the depth of the packer assembly as determined by physical measurement could not be reconciled with the recorded depths of casing collars and that setting the packer assembly at the planned desired setting point may result in the packer assembly's sealing elements 212 being set against a casing joint. It is suggested that in most cases, the planned setting point could be adjusted by a small distance to reconcile it with the detected locations of casing collars.

If and when it has been determined to set the packer assembly 200 at the adjusted planned setting point, the locator and setting tool 70 and packer assembly 200 is then lowered to the adjusted setting point and then raised the "offset distance" measured previously and the packer assembly 200 set. Once this has been, the packer assembly 200 should be in position to be set at the approximate location of the desired setting point.

It is noted that setting of the packer assembly 200 by means of the setting section 74 will result in control-

led, even and centralized setting of the slips and sealing elements 212 against the walls of the wellbore 56. This affords an advantage over those prior art systems which employ explosive charges to set packer assemblies. Use of explosive charges can cause these elements to deform during setting or become set off-center or skewed in the wellbore.

The tool 70 is further preferably designed to permit an extended duration setting sequence for the packer assembly 200. In most instances and constructions, the setting sequence requires more than one minute of setting time to move portions of the packer assembly 200 from an unset condition to a set condition in the wellbore. Optimally, setting times of greater than five minutes are obtained.

It is further noted, although not described in any detail here, that the emplaced packer assembly 200 may have a tubing string (not shown) subsequently latched into it for use in production of hydrocarbons from a zone below the packer. The tubing string may be removed and the packer assembly retrieved by a number of methods. Among these are the use of an Otis VRT Retrieving Tool commercially available from Halliburton Energy Services, 2601 Beltline Road, Carrollton, Texas 75006, (214) 418-3000. This type of removal involves engaging a portion of the packer assembly's guide tube 202 and jarring upward to remove the packer assembly.

The setting section 74 may be thought of as providing a working assembly which is engageable with portions of the packer assembly 200 to set it. The working assembly of the setting section 74 may further be thought of as having inner components, including the threaded shaft 142 with its lower extension 148, which are radially surrounded by outer components, including sleeve 166, which are each engageable with a portion of a barrier member to be set within a string of tubular members. When so engaged, the inner and outer components are axially moveable in opposite axial directions relative to each other to set the barrier member. Although in the preferred embodiment described herein the inner components are moved in a downward axial direction with respect to the outer components to accomplish setting of the packer assembly 200, it should be understood that constructions would be possible wherein a barrier member would be set when the inner components are moved axially upward with respect to the outer components.

Additionally, it should be pointed out that the setting section described with respect to the present invention may be configured to engage and unset particular barrier members as well as set them. One example is the wireline-retrievable "Monolock" tubing string lock available from Halliburton Energy Services.

It will, therefore, be readily understood by those persons skilled in the art that the present invention is susceptible of a broad utility and application. Many embodiments and adaptations of the present invention other than those herein described, as well as many variations, modifications, and equivalent arrangements will be apparent from or reasonably suggested by the present invention and the foregoing description thereof, without departing from the substance or scope of the present invention. For example, the locator and setting tool 70 may be disposed into a wellbore using tubing conveyance rather than wireline disposal. Alternatively, the variations of the apparatus described herein may be used for location and setting of other types of barrier members, such as nippleless locks, within other types of strings of tubular members.

Claims

1. A locator and setting assembly (70) for use in setting of a barrier member (200) at a desired setting point within a string (50) of tubular members in a wellbore (56), the locator and setting assembly being operably connectable to a barrier member setting tool and comprising:

   a. a joint locator (72) capable of detecting the location of joints (62) between the tubular members of said string; and
   b. a setting assembly (74) which is capable of setting a barrier member (200) within the wellbore.

2. An assembly according to claim 1, wherein said joint locator (72) includes a detection means comprising a magnet and coil assembly (100) which senses the location of tubular member connections (62) through magnetic coil induction.

3. An assembly according to claim 1, wherein said joint locator (72) includes a means for generating a signal (100) representative of the location of a joint (62) and transmitting said signal to a remote location.

4. An assembly according to claim 1, 2 or 3, wherein said setting assembly (74) comprises a linear drive working assembly (138, 142, 199) which is engageable with portions of a barrier member (200) for setting of the barrier member within a string of tubular members.

5. An assembly according to claim 4, wherein said linear drive working assembly comprises an inner member (142), affixable to a portion of said barrier member (200), and an outer member (199), also affixable to a portion of said barrier member (200), said inner and outer members being moveable in opposite axial directions relative to each other to set said barrier member (200).

6. A method of setting a barrier member (200) within

a string (50) of tubular members in a wellbore (56), which method comprises the steps of:

a. establishing a desired setting point within said string (50), said desired setting point being based in part upon the recorded locations of joints (62) between tubular members in said string (50);
b. sensing the actual location of at least one joint (62) between tubular members in said string (50);
c. establishing an adjusted desired setting point based upon said sensed actual location; and
d. setting said barrier member (200) proximate said adjusted desired setting point.

7. A method according to claim 6, wherein step (d) of setting said barrier member (200) is accomplished without the use of an explosive charge.

8. A method according to claim 6 or 7, wherein said barrier member (200) is set using a setting assembly which is actuated by surface transmitted power.

9. A method according to claim 6, 7 or 8, wherein step (d) takes more than one minute.

10. A method according to claim 9, wherein step (d) takes more than five minutes.

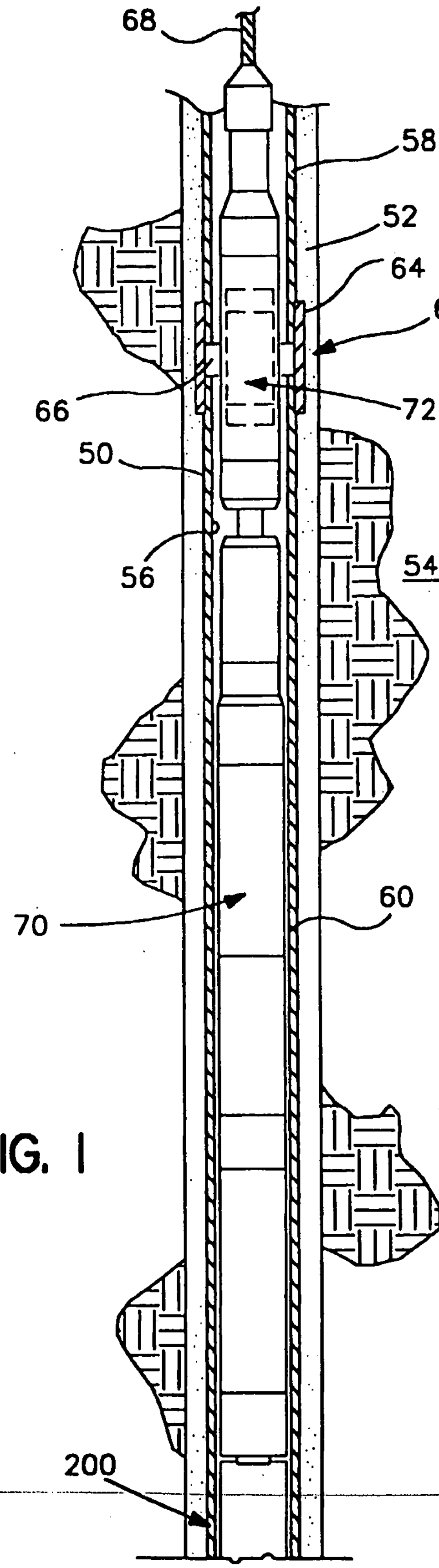


FIG. 1

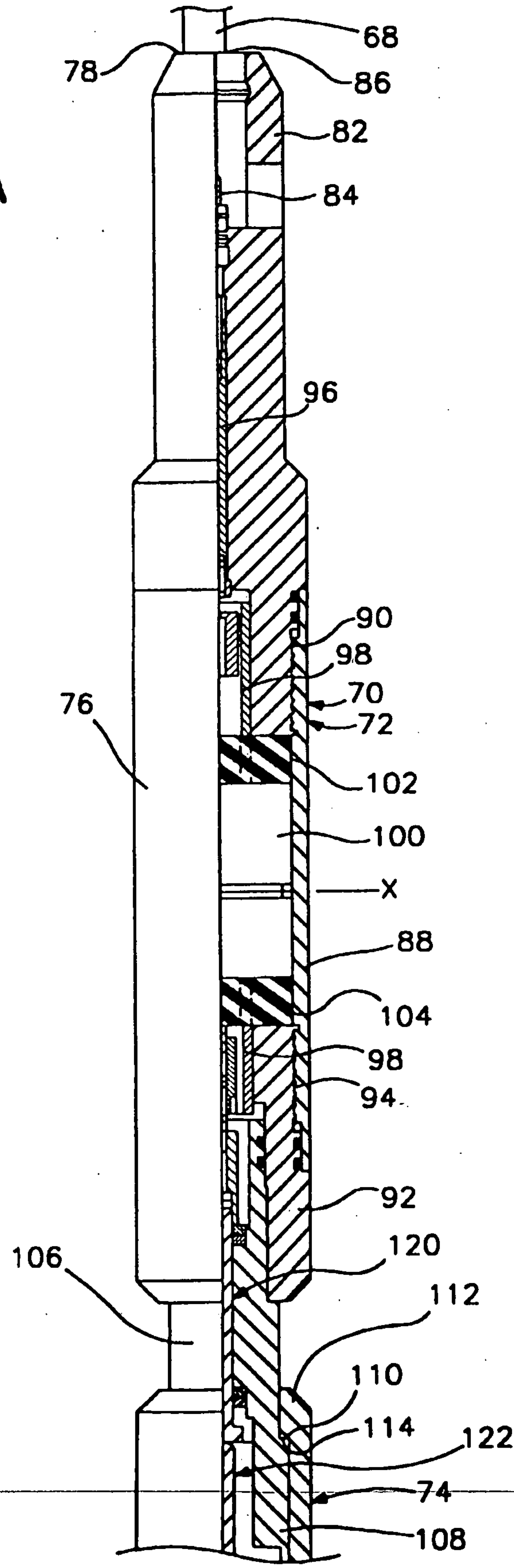

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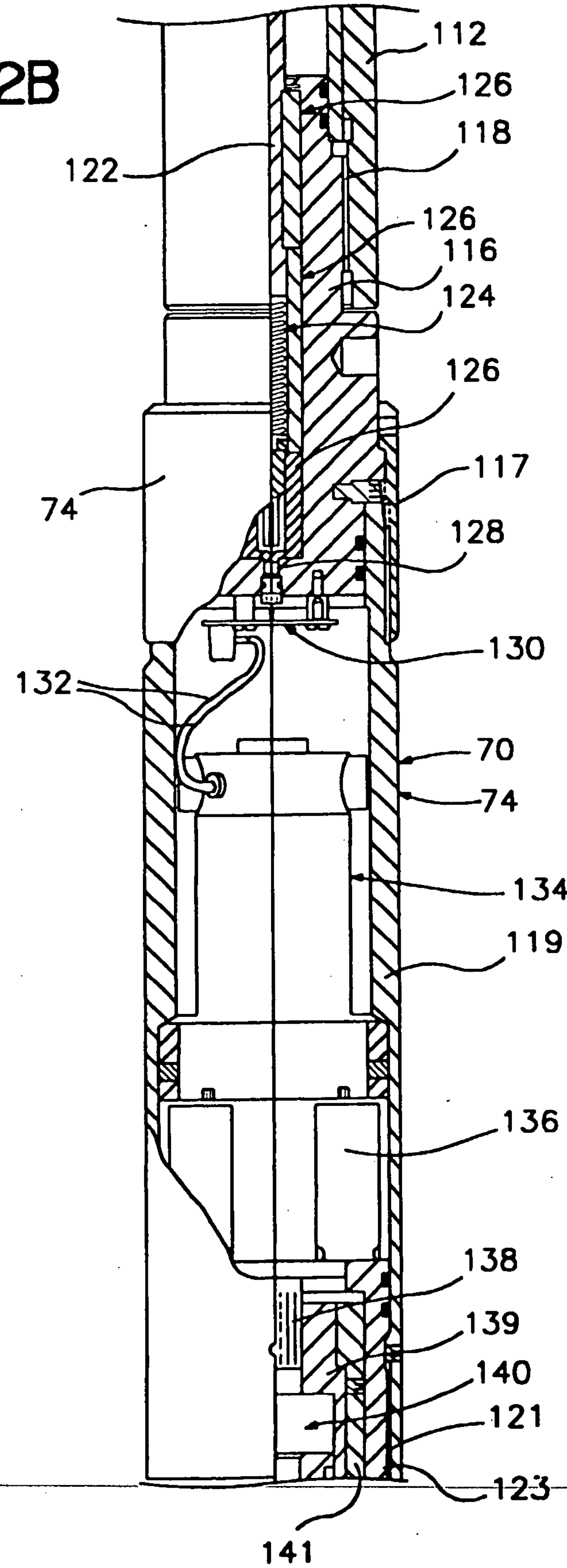
FIG. 2A

FIG. 2B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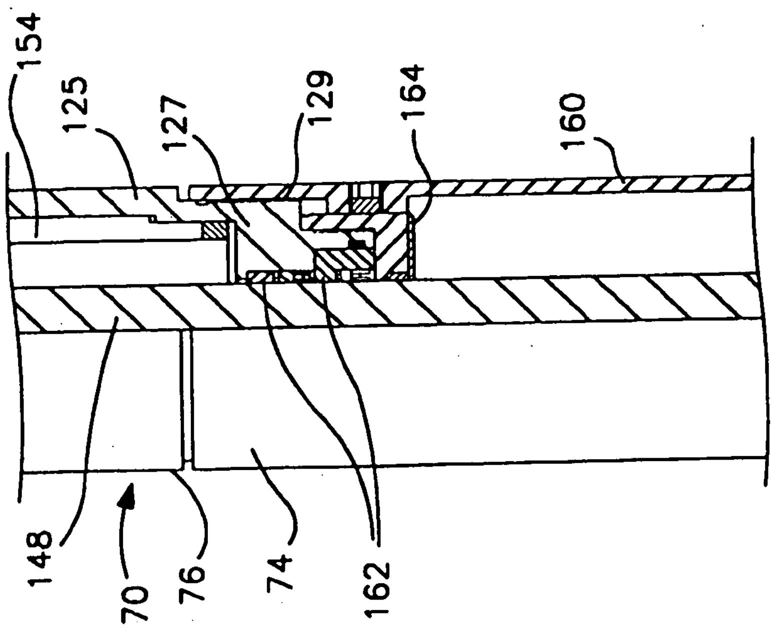


FIG. 2D

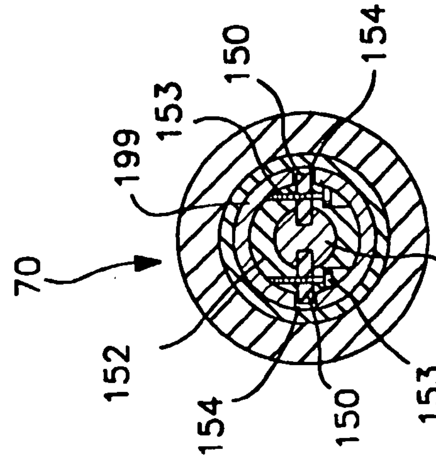
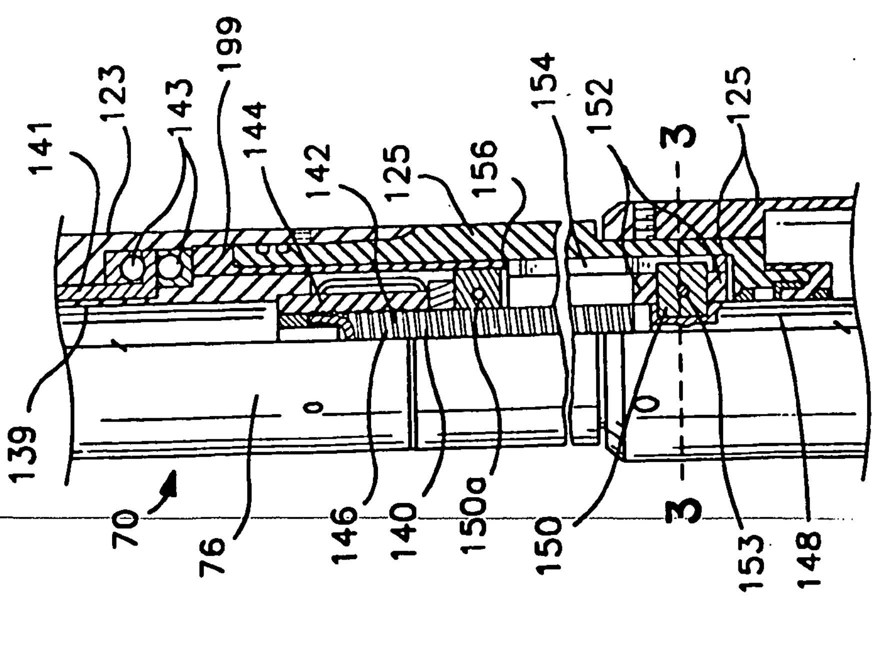


FIG. 3

FIG. 2C



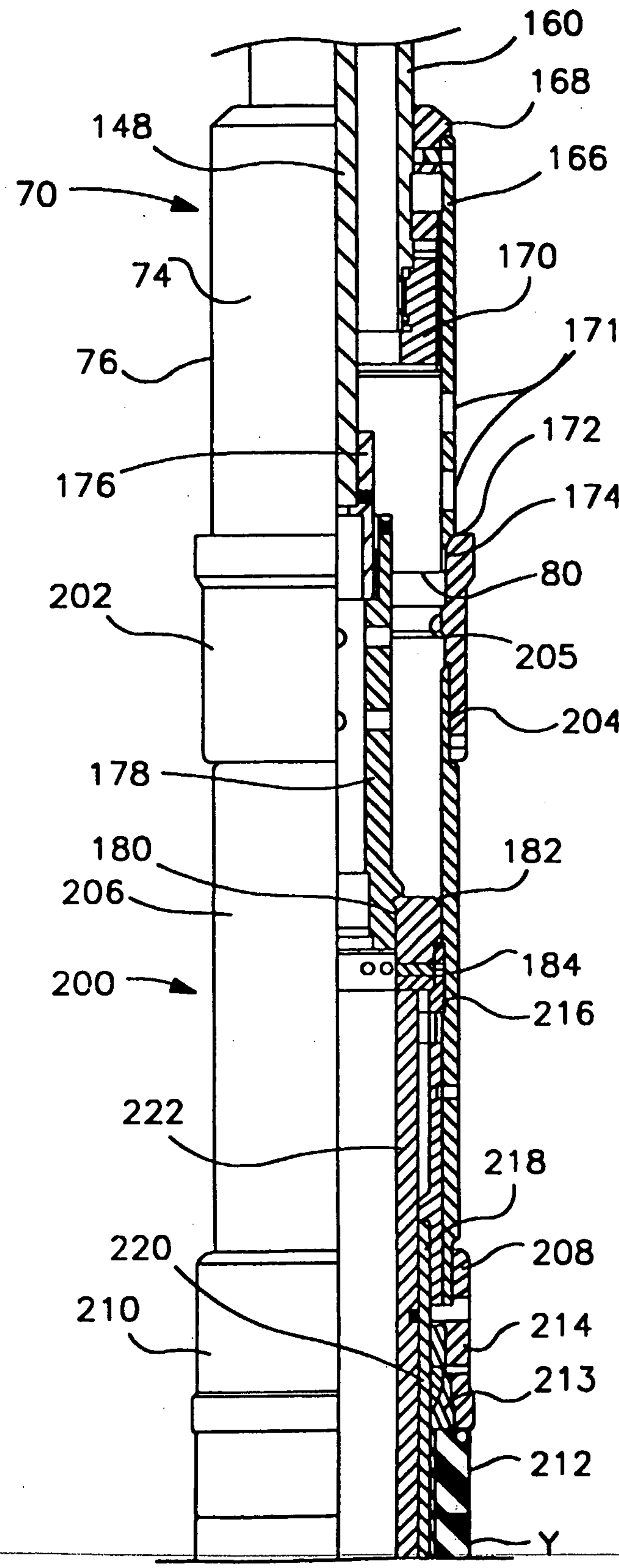

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FIG. 2E